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# MULTIMEDIA UNIVERSITY

## FINAL EXAMINATION

TRIMESTER 3, SESSION 2015/2016

**EEL4126 – POWER SYSTEM OPERATION AND  
CONTROL**  
(LE)

31 MAY 2016  
2:30 PM – 4:30 PM  
( 2 Hours )

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### INSTRUCTIONS TO STUDENT

1. This Question Paper consists of five pages including the cover page with four Questions only.
2. Answer **ALL** questions. All questions carry equal marks and the distribution of the marks for each question is given.
3. Please print all your answers in the Answer Booklet provided.

**Question 1**

(a) Explain the meaning of Economic Dispatch. [2 marks]

(b) The cost characteristics of three units in a plant are:

$$C_1 = \alpha_1 + 150 P_1 + 0.40 P_1^2 \text{ R/h}$$

$$C_2 = \alpha_2 + 130 P_2 + 0.45 P_2^2 \text{ R/h}$$

$$C_3 = \alpha_3 + 120 P_3 + 0.55 P_3^2 \text{ R/h}$$

where  $P_1$ ,  $P_2$  and  $P_3$  are power output in MW and R is the unit of cost.

(i) Find the optimum load allocation between the three units when the total load is 562.5 MW. [7 marks]

(ii) What will be the daily loss if the units are loaded equally? [3 marks]

(c) The incremental fuel cost in \$/MWh for four units of a plant are

$$IC_1 = 0.008P_1 + 9.0$$

$$IC_2 = 0.0068P_2 + 7.0$$

$$IC_3 = 0.012P_3 + 6.0$$

$$IC_4 = 0.0096P_4 + 8.5$$

Assume that all four units operate to meet the total load of 900 MW.

(i) Find the incremental fuel cost of the plant,  $\lambda$  [3 marks]

(ii) Design your system such that each unit of the thermal plant is generating at the most economical condition. [Hint: find the optimal dispatch for each unit]. [5 marks]

(iii) Assume that maximum and minimum loads on each of four units are

Unit	Min in MW	Max in MW
1	100	300
2	50	400
3	80	300
4	110	250

With these maximum and minimum limits, find the economic dispatch.

[5 marks]

Continued...

**Question 2**

- (a) Briefly explain the contingency analysis procedure for a power system. [8 marks]
- (b) Discuss the advantages and disadvantages of using sensitivity factors for contingency analysis. [5 marks]
- (c) The line reactances of a power system shown in Fig. Q2 are:  $x_{12} = x_{23} = x_{31} = 0.2$  pu. Take Bus 3 as the reference bus.
- (i) Calculate the generation shift sensitivity factor for line 1-2 for a shift in generation at Bus 2. [7 marks]
- (ii) Compute the line outage distribution factor for line 2-3 for an outage of line 1-2. [2 marks]
- (iii) What will be the change in line flow in line 1-2 if G2 is outaged. [2 marks]
- (iv) Determine the change in line flow in line 2-3 after the outage of line 1-2 using line outage distribution factor computed in (ii). [1 mark]

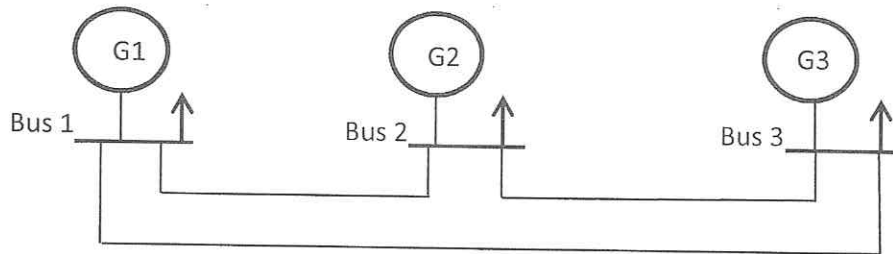


Fig. Q2

[Hint: The generation shift factor

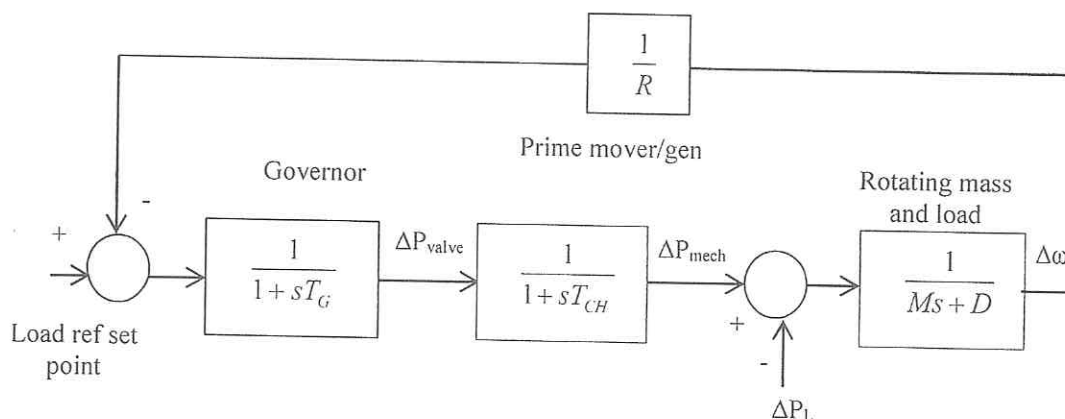
The line outage distribution factor for line  $l$  connected between buses  $i$  and  $j$  for an outage of line  $k$  connected between buses  $n$  and  $m$  is given by

$$\frac{x_k (X_{in} - X_{jn} - X_{im} + X_{jm})}{x_l (x_k - (X_{nn} + X_{mm} - 2X_{nm}))}$$

Continued...

**Question 3**

- (a) The block diagram of a power system consisting of a governor, a prime mover and generator, and load models is given below.



- (v) Explain the function of each component of the system. [7 marks]  
 (vi) Derive the overall transfer function relating system frequency and the load. [4 marks]  
 (vii) Derive an expression for frequency deviation at steady state. [4 marks]

- (b) A power system consists of two areas connected by a tie line with the following characteristics.

Area 1  
 $R = 0.02$  pu  
 $D = 0.8$  pu  
 Base MVA = 500

Area 2  
 $R = 0.04$  pu  
 $D = 1.0$  pu  
 Base MVA = 500

A load change of 200 MW occurs in area 1. Compute the new steady-state frequency and the change in tie flow. Assume both areas were at nominal frequency of 50 Hz to begin with. [7 marks]

- (c) What are the three main objectives of Automatic Generation Control? [3 marks]

Continued...

**Question 4**

(a) What are the functions of an excitation system used for synchronous machines?  
[3 Marks]

(b) The Automatic Voltage Regulation (AVR) system of an alternator has the following parameters:

	Amplifier	Exciter	Alternator	Sensor
Gain	$K_A$	1	1	1
Time constant	0.1	0.4	1.0	0.05

Draw the AVR block diagram. Compute the steady state error for the unity step response if the amplifier gain is 20.  
[10 marks]

(c) For a power plant that has three units with the following cost characteristics:

$$C_1 = 350 + 7.5 P_1 + 0.0040 P_1^2 \text{ \$/h}$$

$$C_2 = 500 + 7.3 P_2 + 0.0045 P_2^2 \text{ \$/h}$$

$$C_3 = 600 + 6.2 P_3 + 0.0055 P_3^2 \text{ \$/h}$$

$P_1$ ,  $P_2$  and  $P_3$  are generating power in MW. The maximum and minimum loads allowable on each unit is 400 MW and 50 MW, respectively.

- What do you understand on the Priority-list Scheme used in Unit Commitment?  
[2 marks]
- Obtain the priority list based on full-load average production cost.  
[4 marks]
- Find the unit commitment using Priority List Algorithm if the system loads varies from 300 MW to 1200 MW in steps of 100 MW.  
[6 marks]

**End of Paper.**